Beneficial land use change

Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture

Göran Berndes, Chalmers University of Technology, Sweden

UPTAKE Webinar: *Sustainable bioenergy crops and beneficial land-use change under changing climates*

9 April 2025

Nothing new…ancient knowledge, sometimes difficult to communicate today due to narratives that convey a strong skepticism towards bio-based solutions

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Editorial

Biofpr Biofuels Bioproducts & Biorefining

May we have some more land use change, please?

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Perhaps the most evident human change to the Earth system is the conversion of a range of ecosystems into land for agriculture and forestry, i.e., for biomass production. To serve our needs, almost half the planet's land area has undergone this kind of change, and we have caused extensive land degradation and biodiversity loss. A majority of ecosystem services are being degraded or used unsustainably. Biodiversity loss is of particular concern since the variety of life at the genetic, species, and ecosystem levels is a prerequisite for many of these services, which in turn are essential for sustainability.

Our land use provides food and other products necessary for sustaining the growing human population, so our 'footprint' will continue to be large. Further, attractive biomass production systems need to be developed, along with efficient technologies for converting biomass to fuels and other bio-based products, in order to replace fossil fuels. Expanded consumption of biomass requires deriving feedstocks from landscape management systems that promote biodiversity and provide a broad range of other ecosystem services.

The links between land use change (LUC) and the emerging bioeconomy are the subject of current research efforts and public debate. The focus is mainly on

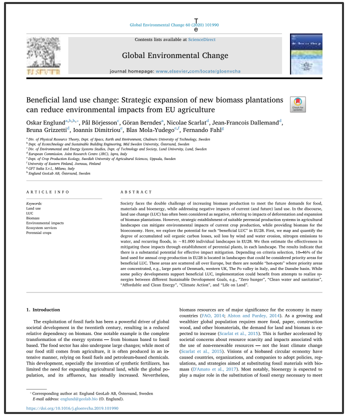
'Possible connections between land use change and the emerging bioeconomy are the subject of current research efforts and public debate'

SCI

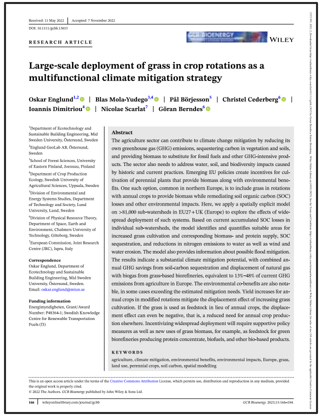
Betsiboka river, Madagascar: LUC-> soil erosion-> sediment transport -> delta growth

Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture

Credits to co-authors!!

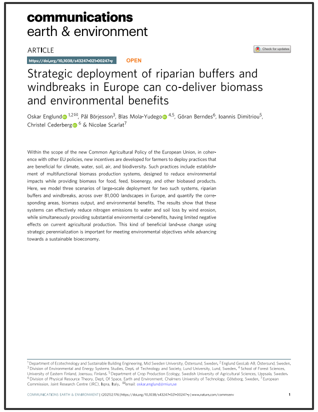

Global Environmental Change

Beneficial land use change: Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture


RESEARCH ARTICLE

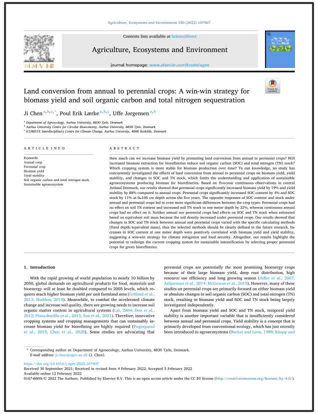
Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy

Oskar Englund | Blas Mola-Yudego | Pål Börjesson | Christel Cederberg | Ioannis Dimitriou | Nicolae Scarlat | Göran Berndes


communications earth & environment

ARTICLE

Strategic deployment of riparian buffers and windbreaks in Europe can co-deliver biomass and environmental benefits


Agriculture, Ecosystems and Environment

Land conversion from annual to perennial crops: A win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration

Ji Chen, Poul Erik Lærke, Uffe Jørgensen

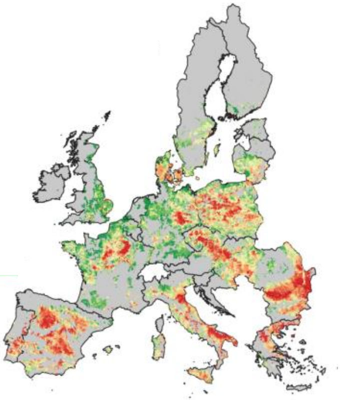

Original Article

Biofpr

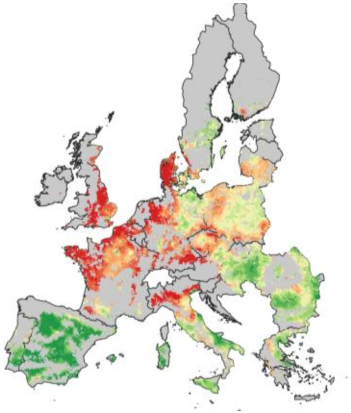
Towards multifunctional landscapes coupling low carbon feed and bioenergy production with restorative agriculture: Economic deployment potential of grass-based biorefineries

Challenges for agriculture in EU

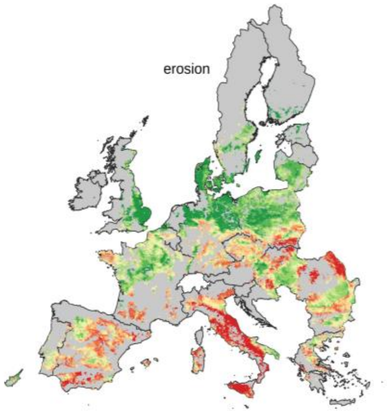
Highest impact | Lowest impact



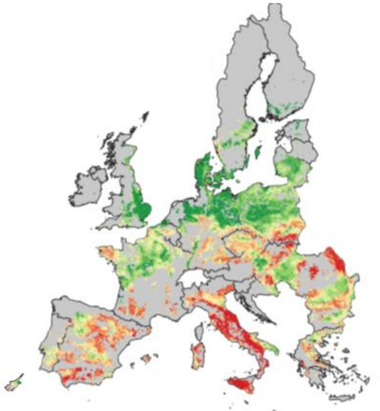
Soil carbon loss



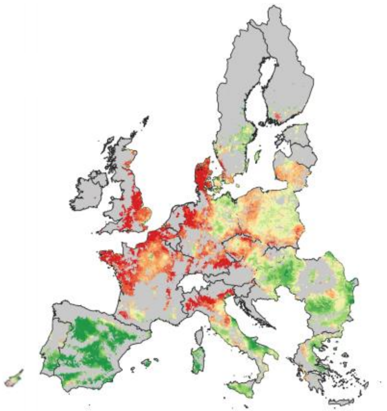
N emissions to water



Recurring floods

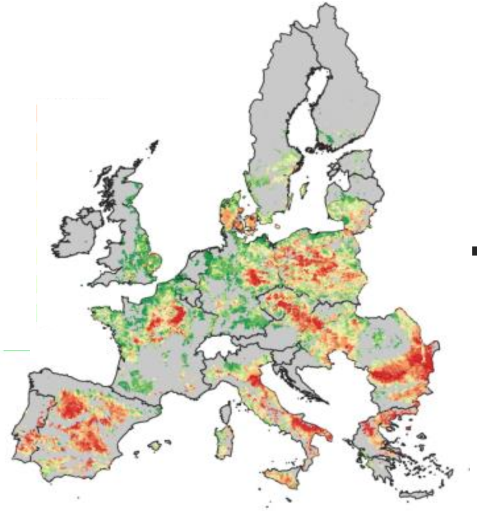


Water erosion



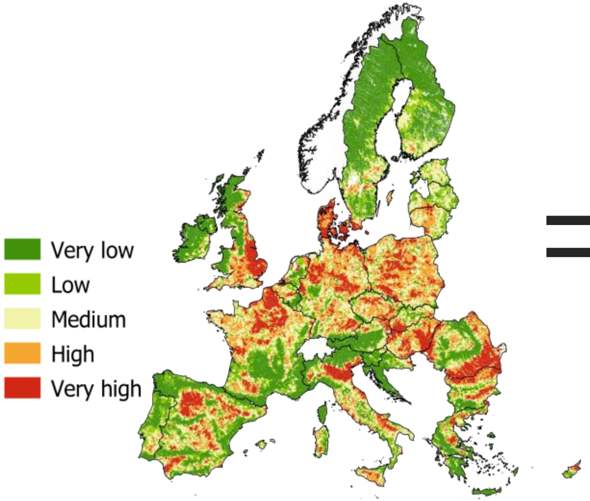
Wind erosion

Strategic integration of perennials



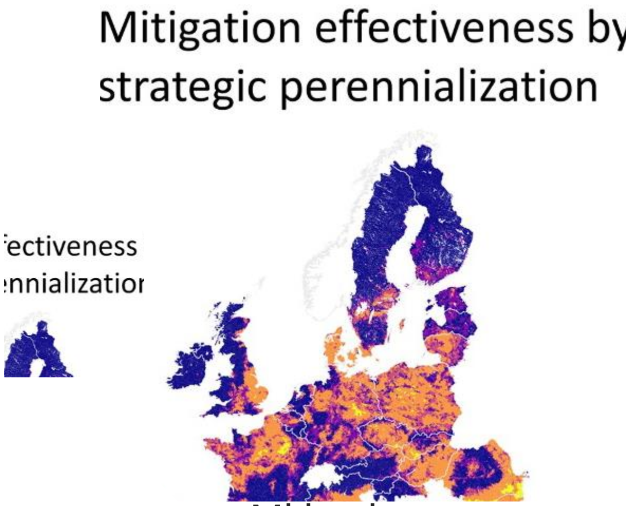
Soil carbon loss

+



Dominance of annual crops

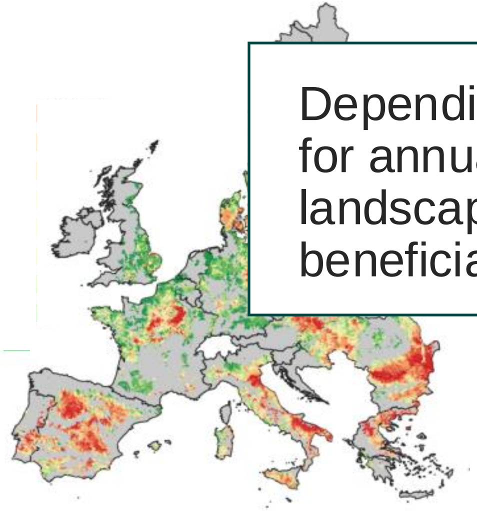
=



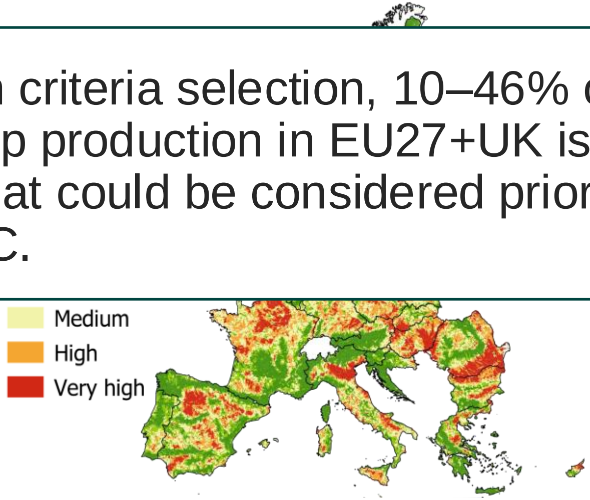
Mitigation effectiveness

Strategic integration of perennials

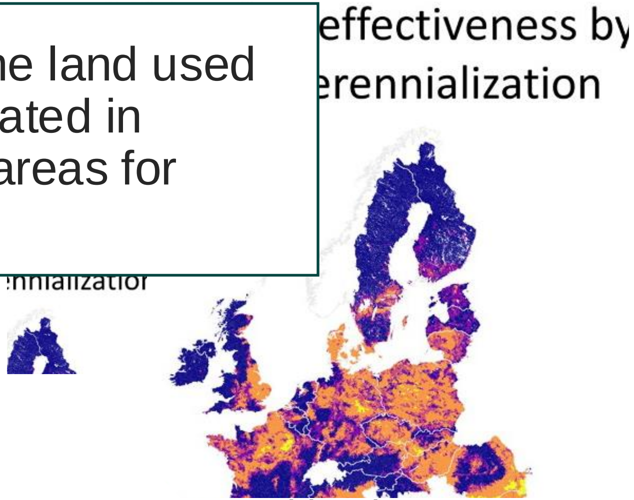
Depending on criteria selection, 10–46% of the land used for annual crop production in EU27+UK is located in landscapes that could be considered priority areas for beneficial LUC.



Soil carbon loss

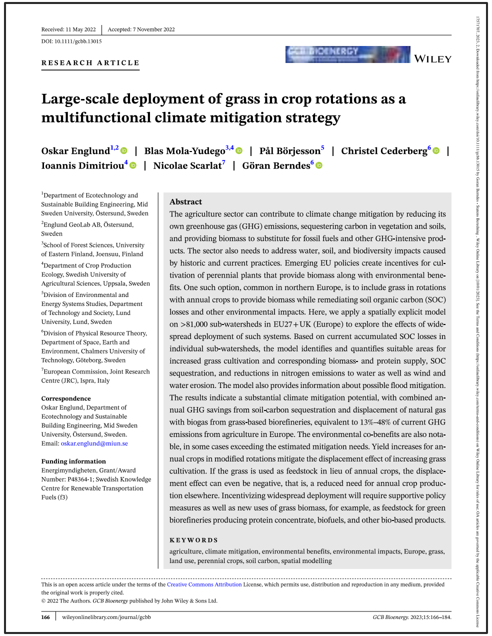


Dominance of annual crops



Mitigation effectiveness

Beneficial LUC & green biorefineries



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GCB BIOENERGY WILEY

RESEARCH ARTICLE

Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy

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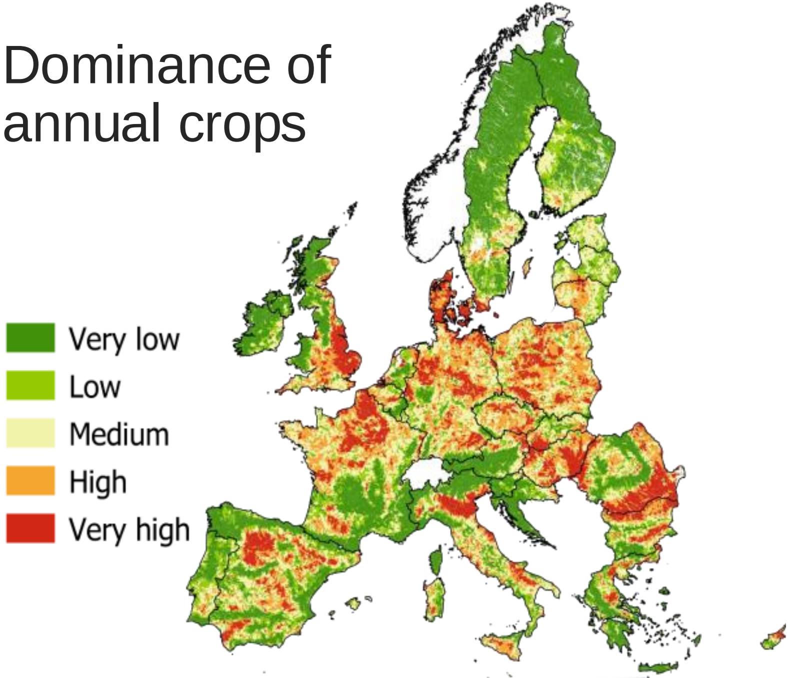
Abstract
The agriculture sector can contribute to climate change mitigation by reducing its own greenhouse gas (GHG) emissions, sequestering carbon in vegetation and soils, and providing biomass to substitute for fossil fuels and other GHG-intensive products. The sector also needs to address water, soil, and biodiversity impacts caused by historic and current practices. Emerging EU policies create incentives for cultivation of perennial plants that provide biomass along with environmental benefits. One such option, common in northern Europe, is to include grass in rotations with annual crops to provide biomass while remediating soil organic carbon (SOC) losses and other environmental impacts. Here, we apply a spatially explicit model on >81,000 sub-watersheds in EU27 + UK (Europe) to explore the effects of widespread deployment of such systems. Based on current accumulated SOC losses in individual sub-watersheds, the model identifies and quantifies suitable areas for increased grass cultivation and corresponding biomass- and protein supply, SOC sequestration, and reductions in nitrogen emissions to water as well as wind and water erosion. The model also provides information about possible flood mitigation. The results indicate a substantial climate mitigation potential, with combined annual GHG savings from soil-carbon sequestration and displacement of natural gas with biogas from grass-based biorefineries, equivalent to 13%–48% of current GHG emissions from agriculture in Europe. The environmental co-benefits are also notable, in some cases exceeding the estimated mitigation needs. Yield increases for annual crops in modified rotations mitigate the displacement effect of increasing grass cultivation. If the grass is used as feedstock in lieu of annual crops, the displacement effect can even be negative, that is, a reduced need for annual crop production elsewhere. Incentivizing widespread deployment will require supportive policy measures as well as new uses of grass biomass, for example, as feedstock for green biorefineries producing protein concentrate, biofuels, and other bio-based products.

KEYWORDS
agriculture, climate mitigation, environmental benefits, environmental impacts, Europe, grass, land use, perennial crops, soil carbon, spatial modelling

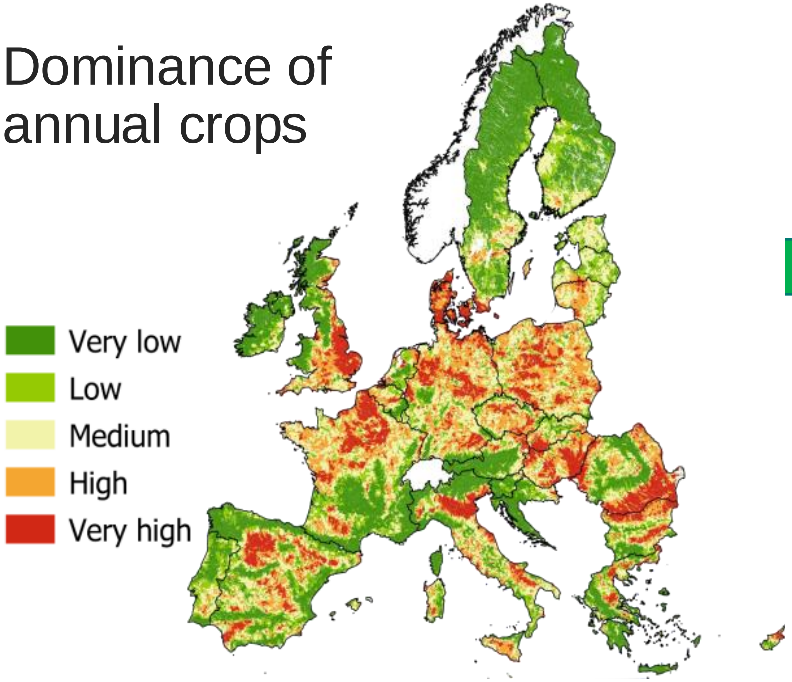
166 | wileyonlinelibrary.com/journal/gcbb *GCB Bioenergy*. 2023;15:166–184.

Dominance of annual crops

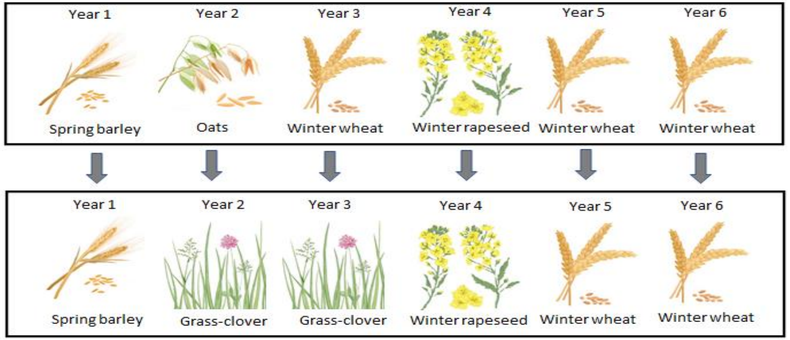


Beneficial LUC & green biorefineries

Dominance of annual crops

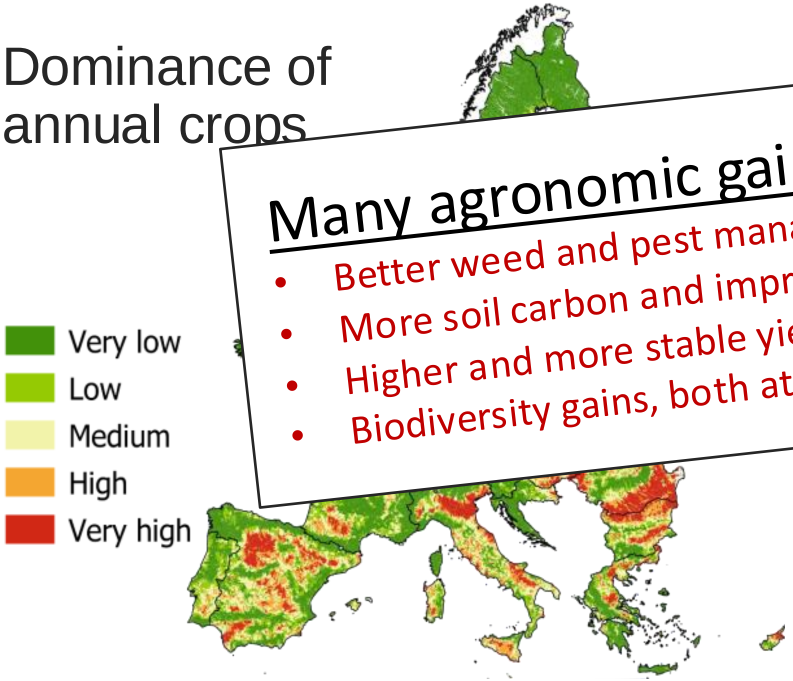


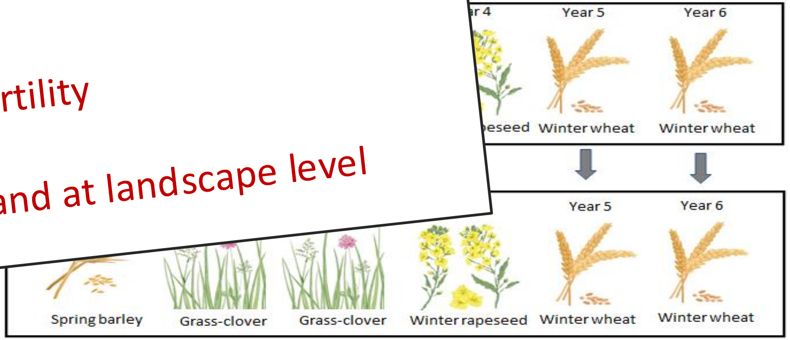
Adjusted crop rotations



Beneficial LUC & green biorefineries

Dominance of annual crops





Many agronomic gains:

- Better weed and pest management
- More soil carbon and improved soil fertility
- Higher and more stable yields
- Biodiversity gains, both at field level and at landscape level

Beneficial LUC & green biorefineries

cereals

grass-clover ley in rotation

biorefinery

- soil carbon increase
- biochar
- biomethane subst. fossil gas
- protein feed subst. soymeal
- reduced need for synthetic fertilizers

Beneficial LUC & green biorefineries

cereals

Indication of potential in EU:

Large-scale deployment of grass-clover ley in crop rotations can produce biomethane on par with Repower EU 2030 target

crease

bst. fossil gas

bst. soymeal

reduced need for synthetic fertilizers

Beneficial LUC & green biorefineries

cereals

Indication of potential in EU:

Soil carbon storage & fossil gas substitution

-> annual GHG savings: up to 50% of current agriculture emissions in EU

rease

st. fossil gas

st. soymeal

reduced need for synthetic fertilizers

Beneficial LUC & green biorefineries

cereals

Displacement effects:

- reduced area with annual crops
- but higher yields in crop rotation and reduced need for soy cultivation

-> net effect? possibly land savings

crease

bst. fossil gas

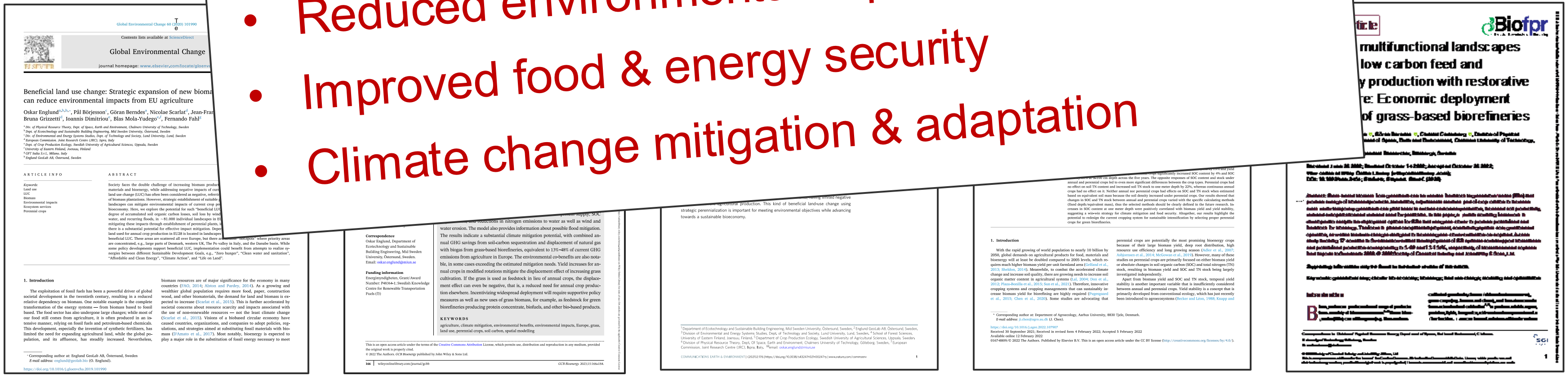
bst. soymeal

or synthetic fertilizers

CHALMERS

Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture

- Reduced environmental impacts in agriculture
- Improved food & energy security
- Climate change mitigation & adaptation



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CHALMERS

Strategic expansion of new biomass plantations can reduce environmental impacts from EU agriculture

Example drivers

- EU water directive (do *perennials to reduce leakage*)
- Economic support for carbon farming & soil restoration
- Gas import dependency
- Protein import dependency (84% of soy imported to EU)

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